

Operational Plan

Electronics and Electrical Engineering Laboratory

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Introduction

This document provides a high-level view of how the Electronics and Electrical Engineering Laboratory (EEEL) portfolio of research, services, and collaborations support the NIST strategic goals as outlined in the NIST 2010 Strategic Plan, which can be accessed by NIST staff at <http://www-i.nist.gov/HyperNews/director-mod/get/focusnist.html>. These goals include:

1. Research and develop the measurements and standards needed to support emerging science and technology-intensive industries. Specifically, NIST has chosen to focus on the emerging areas of health care quality assurance; nanoscale measurements and data; and information / knowledge management.
2. Develop and efficiently disseminate the measurements and standards needed to support the Nation's strategic interests in homeland security. NIST's efforts support cyber security and critical infrastructure protection; chemical, biological, radiological, nuclear and explosives detection and security; as well as other homeland security needs.
3. Assure the availability and efficient transfer of measurement and standards capabilities essential to established industries. This goal supports the current needs of the traditional EEEL customer base.

Industry Focus for EEEL Programs

The mission of the EEEL is to strengthen the U.S. economy and to improve the quality of life by providing measurement science and technology, and by advancing standards, primarily for the electronics and electrical industries.

The U.S. economy depends critically on new technology as the basis for new and improved products. New technology requires supporting measurement science and measurement technology. By providing these, EEEL enhances productivity, facilitates trade, and improves the quality of life. Measurement science and technology are part of the national infrastructure that helps promote and retain businesses and jobs.

The principal customer industries of EEEL are the electronics and electrical industries. The electronics industries include manufacturers of electronics systems; optical, magnetic and electronic component suppliers; the telecommunications firms and their suppliers; companies that rely heavily on electronics such as aerospace and automotive firms; and companies that enable guided-wave and free-space electromagnetic technologies. The electrical industries include the electric-power and the electrical-equipment industries and their suppliers, which together generate, distribute and store electricity and convert electricity into other useful forms, through products such as motors, lights, and heating elements. All other industries, government agencies, and the public rely on these industries for critical products and services. EEEL also serves the criminal-justice and public-safety communities; the academic research community; and serves and collaborates with other government agencies such as DoD, NASA and NIH. All services are designed to benefit the ultimate customer of EEEL: the public.

EEEL is composed of a headquarters, six divisions and two offices. Together they conduct four major programs:

Program 1: Foundation for All Electrical Measurements

Program 2: Electronics Industry

Program 3: Electrical Industries

Program 4: Criminal Justice and Public Safety

The first program focuses on strengthening the foundation for all electrical measurements. This program supports all U.S. industries and underpins the work in the next three programs. It represents the Laboratory's top priority due to mandated responsibilities as the nation's metrology institute. The other three programs provide measurement capability needed by the Laboratory's principal customers: the electronics industry; the electrical industries; and the criminal-justice and public-safety communities. These overarching programs are described in greater detail in the EEEL 2002 Strategic Plan, which can be found on the EEEL external website at http://www.eeel.nist.gov/lab_office/documents/2002/EEEL%20Strategic%20Plan.pdf.

Through its commitment to understanding and meeting the needs of the industries it serves, EEEL not only contributes to the core mission of the Institute but also aligns itself with the NIST strategic goals in nanotechnology (through the Foundation for All Electrical Measurements and Electronics Industry programs), health care (through the Electronics Industry program), information/knowledge management (through the Electronics Industry program) and homeland security (through the Electronics Industry, Electrical Industries, and Criminal Justice and Public Safety programs).

EEEL has made the Institute's most substantial investment in nanotechnology, in such areas as the development of quantum-based standards, support for current semiconductor fabrication processes as well as for CMOS alternatives, and the development of standards for NanoElectroMechanical Systems (NEMS) manufacturing practices. The EEEL Office of Microelectronics Programs currently invests 60% of its annual \$12.4M budget in nanotechnology, and expects that investment to increase 7% per year. By addressing industry's need for a solid foundation for the nation's information and telecommunication infrastructure and the more efficient flow of information between companies, EEEL also supports the NIST strategic focus on information and knowledge management. With an annual budget now exceeding \$17M, the EEEL Office of Law Enforcement Standards contributes to the Institute's strategic goals while working with criminal justice and public safety agencies to meet the Nation's security objectives. Finally, EEEL supports the Institute's strategic objectives by impacting the quality of health care through a number of programs: by helping the medical instrument community ensure that they can accurately calibrate their laser- and display-based systems; through working on the characterization of electromagnetic fields radiating from cellular telephones; and through the competence building Single Molecule Manipulation and Measurement (SM³) program that is developing metrology at the cellular level.

Alignment of Strategic and Operational Plans

The following tables show how EEEL is currently aligned with NIST's strategic goals, and how that alignment is maintained and enhanced through anticipated reprogramming in FY03 and FY04. Although EEEL has already made a significant investment in nanotechnology, the tables reflect that investment is expected to grow significantly in the upcoming years. Laboratory investment in critical infrastructure protection is expected to decline, primarily due to the loss of one-time funding for FY02. Investment in core metrology programs is expected to remain close to current levels. All financial figures are estimates.

NIST-WIDE STRATEGIC DIRECTION		EEEL OPERATIONAL PLANS		
Strat. Goals	Research / Technology Focus Areas	Programs and goals	Approximate FTE and \$ to be used in FY03 and FY04	Significant outcomes expected over time
1. Research and develop the measurements and standards needed to support emerging science and technology-intensive industries	Health care quality assurance	<ul style="list-style-type: none"> Medical imaging and equipment Single molecule manipulation and measurement Characterization of electromagnetic fields from cellular telephones 	FY02: \$2.5M STRS \$1.5M OA \$0.2M Reimbursable 18 FTE <hr/> FY03: \$2.6M STRS \$1.5M OA \$0.3M Reimbursable 18 FTE <hr/> FY04: \$2.7M STRS \$1.6M OA \$0.3M Reimbursable 18 FTE	<ul style="list-style-type: none"> Reliable laser-based and image-based medical equipment. High throughput and single-molecule measurement capabilities for pharmaceutical biotech R&D. Contribute to public safety in the ubiquitous use of cellular telephones through the quality assurance of the measurements. Commodity exchange standards for superconducting magnets used in Magnetic Resonance Imaging. Magnetic sensors for medical imaging of heart and brain functions.
	Nanoscale measurements and data	<ul style="list-style-type: none"> Nanomagnetics Nanoelectronics Nanomaterials characterization Basic nanoscale metrology Nanobiotechnology Quantum devices & measurements 	FY02: \$10.8M STRS \$3.3M OA \$0.6M Reimbursable 71 FTE <hr/> FY03: \$12.4M STRS \$3.4M OA \$0.6M Reimbursable \$1.1M Initiative 75 FTE <hr/> FY04: \$13.7M STRS \$3.5M OA \$0.7M Reimbursable \$1.4M Initiative 79 FTE	<ul style="list-style-type: none"> Metrology infrastructure for CMOS alternatives. Commercial semiconductor manufacturing processes and test equipment compatible with use of ultrathin and alternative gate dielectrics. Standard manufacturing practices for NanoElectroMechanical Systems. Magnetic devices for information processing based on switching of single spins. Quantum-based standard for optical power. Sources and detectors for single photons. Quantum-based capacitance standard. Quantum-based variable AC-voltage source. Accelerated development of solid state lighting. Higher switching rates and denser magnetic recording media. Provably secure quantum communication link using single photon detector. Advances in the understanding and prototyping of a solid-state quantum computer.

1. Research and develop the measurements and standards needed to support emerging science and technology-intensive industries (continued)	Information / knowledge management	<ul style="list-style-type: none"> Information exchange infrastructure Telecommunications infrastructure and wireless documentary standards 	FY02: \$6.1M STRS \$1.6M OA \$0.9M Reimbursable 35 FTE	<ul style="list-style-type: none"> Efficiency gains in supply chain operations for the production of electronic devices due to globally adopted information exchange standards. Traceable measurements and increased-accuracy dispersion instruments for high data rate optical communications. Traceable wavelength references covering the full telecommunication spectrum. High-speed microcircuits based upon on-wafer measurement methods. Reliable satellite communications based on accurate high-performance antennas. Advances in the fundamental understanding and measurement of complex antenna characteristics. Globally adopted broadband wireless access standards.
	Measurement science for other OU program areas	<ul style="list-style-type: none"> Quantum-based physical and information standards Advanced measurement techniques for electrical and electronic materials, components and systems Evolution and maintenance of fundamental standards Superconductor standards Microscopy and imaging techniques 	FY02: \$14.4M STRS \$3.8M OA \$2.8M Reimbursable 107 FTE	<ul style="list-style-type: none"> Quantum-based electrical thermometry standard. Validated quantum-based standards and physical constants. Traceable measurements for 157nm lithography tools. Highly accurate dispersion instruments enabling high data rate telecommunications. Traceable national standards for quantities such as the volt, ohm, farad, impedance, AC-DC difference, video display characteristics, electrical noise, antenna characteristics, scattering parameters, magnetic field strength, and laser and superconductor characteristics. High accuracy electrical measurements to support high technology advances. Quantum-based electronic mass standard. Efficient application of advanced power devices in the transportation, electric power, and industrial motor drive industries. Advances in the fundamental understanding and measurement of superconductor characteristics for the application of superconductors in power, energy storage and medical magnetic imaging systems.

2. Develop and efficiently disseminate the measurements and standards needed to support the Nation's strategic interests in homeland security	Cyber security and critical infrastructure protection	<ul style="list-style-type: none"> Protection and monitoring of the US electric power system Cyber security/forensic analysis First responder interoperable communications 	FY02: \$2.7M STRS \$0.4M OA \$0.3M Reimbursable 11 FTE <hr/> FY03: \$1.8M STRS \$0.6M OA \$0.3M Reimbursable 11 FTE <hr/> FY04: \$1.9M STRS \$0.6M OA \$0.3M Reimbursable 11 FTE	<ul style="list-style-type: none"> Reduced vulnerability of the electric power system, including control systems. Improved capability to accurately monitor power grid conditions in real time. Improved forensic analysis of recorded media to support cyber security. Improved interoperable communications for first responders.
	Chemical, biological, radiological, nuclear, and explosives detection and security; and other homeland security efforts	<ul style="list-style-type: none"> CBRNE Protective Equipment Guides MEMS-based integrated electronics platform for chemical sensing of biological agents Materials characterization to support improved UV lasers for biological agent sensors Improved x-ray spectroscopy to allow identification of small threat agent particles, in support of CSTL efforts Concealed weapons detection system Electromagnetic shielding and compatibility, radar applications 	FY02: \$6.7M STRS \$3.3M OA \$1.6M Reimbursable 59 FTE <hr/> FY03: \$7M STRS \$3.4M OA \$1.6M Reimbursable 60 FTE <hr/> FY04: \$7.2M STRS \$3.6M OA \$1.7M Reimbursable 61 FTE	<ul style="list-style-type: none"> Accelerated development of a suite of national chemical and biological protective equipment standards. Improved low-cost, portable electronics platform for CB detection systems. Improved UV lasers, LEDs and photodiodes used in biological agent sensors. Commercialized high-resolution microcalorimeter x-ray detector to allow improved small particle (RNE) analysis. Practical, portable active mm-wave system capable of imaging weapons and other objects concealed under clothing. Reduced vulnerability of aircraft and other systems to high intensity electromagnetic fields. More effective radar for identification and detection. Magnetic sensors for weapons and personnel detection.
3. Assure the availability and efficient transfer of measurement and standards capabilities essential to established industries	OU program areas	<ul style="list-style-type: none"> Fundamental electrical standards Electromagnetic fields, emission and immunity Antenna calibrations Standards for optoelectronic components used in telecommunications Laser sources and detector calibrations International comparisons 	FY02: \$14.1M STRS \$4.7M OA \$2.9M Reimbursable 100 FTE <hr/> FY03: \$14.5M STRS \$4.9M OA \$3M Reimbursable 100 FTE <hr/> FY04: \$15.1M STRS \$5.1M OA \$3.2M Reimbursable 100 FTE	<ul style="list-style-type: none"> Equitable marketplace based on traceable national standards for quantities such as the volt, ohm, farad, impedance, AC-DC difference, video display characteristics, electrical noise, antenna characteristics, scattering parameters, magnetic field strength, and laser and superconductor characteristics. High accuracy electrical measurements to support high technology advances. Traceable measurements for 157nm lithography tools. Highly accurate dispersion instruments enabling high data rate telecommunications. Internationally adopted system of weights and measures. Test methods to industry to assure electromagnetic compatibility of all electronic products.

Program Descriptions

Measurements and Standards Supporting Emerging Science and Technology Intensive Industries

Health Care Quality Measurements

EEEL supports the health care industry with a range of programs. In the area of medical imaging and equipment, EEEL provides standards for flat-panel display metrology that enable physicians to reliably perform remote diagnoses and archive medical images. EEEL is developing fundamental health care standards, such as for electromagnetic shielding of medical equipment, calibrates laser sources and detectors used for laser-based medical systems, and is applying magnetic sensors to the imaging of heart and brain functions. In the area of molecular structure and dynamics, EEEL is coordinating the competence-building program “Single Molecule Manipulation and Measurement” (SM³), which is focused on the development of a NEMS-based platform to transport single biomolecules (such as DNA and proteins) to stations where electronic, optical, and mechanical measurements are made on them in order to study their structure and dynamics. EEEL is considering expanding this work into bioelectronics, which would allow the electrochemical probing of the response of cells to toxins. In the area of public health, EEEL is funded by NIH to characterize the electromagnetic fields from cellular telephones. EEEL may also augment its NIH support with related research programs in electromagnetic compatibility.

Nanoscale Measurements and Data

Due in large part to increasing industry pressure from the semiconductor and magnetic data storage industries for ever-smaller critical dimensions, EEEL has a substantial and growing investment in nanoscale measurements and research which supports all of the focus area’s subcategories. In support of nanoscale metrology, EEEL is developing quantum-based standards in the areas of optical power, capacitance and current, AC voltage and thermometry. In nanoelectronics, EEEL has a suite of projects that will help the semiconductor industry achieve and measure nanoscale critical dimensions, and is also characterizing materials, establishing manufacturing practices and laying the metrology foundation for CMOS alternatives such as molecular electronics. The Laboratory’s SM³ program supports nanobiotechnology by connecting nanoscale electronics to molecular systems and developing manufacturing practices for NanoElectroMechanical Systems (NEMS). Also related to nanomaterials characterization, EEEL is accelerating the development of solid state lighting through its effort to develop tools and characterize wide bandgap III-nitride alloys. EEEL is also doing revolutionary work towards the development of a Josephson-Junction-based quantum computer, and the establishment of “provably secure” quantum communications links using single photon detectors. EEEL has an active program in nanomagnetism, which is working with industry to develop new techniques to measure and control spin characteristics in small spin-based devices, with the hope of measuring systems consisting of only a single spin.

Information/Knowledge Management

EEEL supports this strategic focus area in two ways: through the creation of the physical infrastructure for information and telecommunications, and through the development of documentary standards for information exchange in the electronics industry. EEEL carries out a robust suite of projects that support high-data-rate optical communications, and provide traceable measurements and wavelength references covering the full telecommunication spectrum. EEEL is advancing the fundamental understanding of the measurement of complex antenna characteristics, provides calibration services for high performance antennas such as those used for satellite communications, and is developing improved measurement methods for radar applications. Programs in RF technology are advancing the state of the art for high frequency digital and analog microelectronics, and providing reliable on-wafer test methods.

EEEL has worked with industry through IEEE to develop broadband wireless access standards that provide a common format upon which to build a marketplace of cost-effective, ultra-high-bandwidth commercial wireless services. EEEL has also worked with the circuit assembly industry to establish a portfolio of documentary standards for efficient, multi-company global manufacturing operations.

Measurement Science

A solid metrology foundation requires ongoing research in measurement science, and each of the Laboratory's service-delivery projects maintains an active research component. The Laboratory's metrology science lays the foundation to support industry's future needs, and provides global leadership to other metrology institutes. EEEL often provides the world's best available accuracy and most complex metrology services.

Measurements and Standards Supporting Strategic Interests in Homeland Security

EEEL supports improved Homeland Security through research programs within EEEL and through projects supported by the EEEL Office of Law Enforcement Standards (OLES) across NIST and outside NIST with funding primarily from the National Institute of Justice. OLES is the unifying agent within EEEL for homeland security efforts, providing leadership, high-level contacts with outside agencies, and outside agency funding to address pressing homeland security needs. OLES focuses on the development of performance standards, which are promulgated as voluntary national standards by the NIJ. OLES also conducts research on protective clothing, communication systems, emergency equipment, investigative aids, protective and enforcement equipment, security systems, traffic enforcement systems, vehicles, weapons and ammunition, and analytical techniques and standard reference materials (SRMs) used by the forensic science community. OLES funding has increased substantially following September 11 from approximately \$14M to \$17.7M, and is expected to continue to gradually increase over time. For the purposes of the above funding table, however, we report only funding of Homeland Security efforts within EEEL, some of which is funded by OLES.

Cyber Security and Critical Infrastructure Protection

To protect our nation's critical infrastructure, EEEL has an active program to advance electric power metrology to ensure the security of the U.S. electric power system. This effort has benefited from an additional \$1M in supplemental CIP funding during FY02, which has supported increased cyber security efforts related to integrating web-based systems and sensor networks for the U.S. electric power system. In support of increased cyber security and investigation of suspected cyber-terrorists, EEEL has a growing effort (supported by the FBI and others, including OLES) to develop arrays of small magnetic sensors to quickly read a variety of recorded media, including damaged media such as incompletely erased audiotape, fragments of airplane "black box" recordings, and crashed hard drives. In addition, OLES funds complementary cyber security efforts in ITL to streamline law enforcement forensic analysis of computer hard drives through the National Software Reference Library and Computer Forensic Tool Testing projects. EEEL also supports the development of improved interoperable communications for first responders, both within EEEL and through OLES funding of public safety communications work at NTIA.

CBRNE detection and security; and other Homeland Security efforts

EEEL/OLES has a particularly strong effort in CBRNE detection and security through its development of chemical and biological (CB) protection equipment standards, including standards for respirators and CB detection and decontamination technologies; investigating and validating advanced lightweight protective clothing systems; and devising a test laboratory certification program. OLES has accelerated this effort, and has already published the first of a series of CB protection equipment guides for emergency first responders. Additional EEEL CBRNE efforts include developing a MEMS-based integrated electronics platform for chemical sensing of biological agents, and characterizing the optical, structural and electronic properties of the group III-nitrides to enhance the manufacture of UV lasers, LEDs and photodetectors used in biological agent sensors. In collaboration with CSTL, EEEL is also developing advanced microcalorimeter-based x-ray spectroscopy that will support ongoing CSTL efforts to identify small RNE particles for homeland security and military applications.

In addition to its CBRNE efforts, EEEL has significant homeland security programs in concealed weapons detection (portable active mm-wave concealed weapons detection systems, improved metal detector standards and test materials, OLES-supported) and surveillance imaging (liquid-filled camera, OLES-supported), as well as substantial efforts in electromagnetic compatibility testing (reducing vulnerability of aircraft to high intensity electromagnetic fields), antenna calibrations and radar cross-section standards.

Measurements and Standards Supporting Established Industries

The majority of the programs in EEEL are devoted to ensuring that industry has the metrology artifacts, standards, and test methods needed to conduct business within an equitable environment. All of the nation's electrical measurements are traceable to the reference standards and calibration services provided by EEEL, and nearly every industry is impacted by the Laboratory's work. EEEL partners with the aerospace and automotive industries to ensure that electromagnetic interference does not compromise public safety.

EEEL provides services for a broad spectrum of communications technologies, from its calibration services of high-performance antennas used in satellite links, to its reference materials for fiber-optic telecommunications. EEEL provides techniques for on-wafer measurements of electrical waveforms, calibration services for laser sources and detectors, and standards and measurement techniques to ensure uniform characterization of flat-panel displays.

Coordination With Other NIST Operating Units

Since many NIST efforts are by nature interdisciplinary, coordination among the NIST operating units (OUs) is critically important to achieve common strategic goals. In particular, the NIST Strategic Focus Areas (SFAs) require special emphasis on coordination to maximize the Institute's impact in these high-visibility areas. EEEL is in an excellent position to promote such coordination, based on the Laboratory's long history of effective program coordination and project collaboration, both within NIST and with its customers.

Within NIST, EEEL is unique in having two Offices that reach across the Institute's OUs to provide funding and program coordination. EEEL's Office of Microelectronics Programs (OMP) collaboratively manages the Institute's semiconductor metrology efforts, in response to needs expressed in the International Technology Roadmap for Semiconductors (ITRS). EEEL's Office of Law Enforcement Standards (OLES) serves as the Institute's principal agent for standards development for the criminal justice, first responder and public safety communities. Both Offices collaborate with multiple external organizations and actively participate in national strategic planning efforts, in addition to organizing and coordinating cross-OU programs within NIST. The majority of funding provided by each Office goes outside EEEL, and both Offices have already made significant investments to support the NIST SFAs (60% of the OMP \$12.4M budget supports nanotechnology efforts, and virtually all of the OLES ~\$17M OA-funded budget supports homeland security efforts both inside and outside NIST.)

EEEL also actively encourages cross-laboratory collaboration and coordination among the Institute's scientific staff. Recent examples of multi-laboratory research efforts involving EEEL include:

- Single Molecule Manipulation and Measurement. *Joint with the Chemical Science and Technology Laboratory (CSTL) and the Physics Laboratory (PL);*
- Molecular Electronics. *Joint with CSTL;*
- Gallium Nitride Material Characterization. *Joint with CSTL and the Materials Science and Engineering Laboratory (MSEL);*
- Johnson Noise Thermometry. *Joint with CSTL;*
- Microcalorimeter X-Ray Spectroscopy. *Joint with CSTL;*
- Optical Photon Detection. *Joint with PL;*
- Magnetism. *Joint with MSEL/PL;*
- High-Frequency Dielectric Measurements. *Joint with MSEL;*
- Electronic Data Exchange. *Joint with MEL and the Information Technology Laboratory (ITL).*

Additionally, EEEL has provided support to NIST-wide calibration services through the development of the Information System to Support Calibrations (ISSC) and its proposed transfer to Technology Services (TS). While not funded, the recent joint proposal from EEEL, MSEL, and PL to initiate a project to develop high sensitivity nanomagnetic sensors is a good example of a grass-roots EEEL coordination effort in support of all of the Institute's SFAs.

Evaluation of Quality, Relevance, and Performance

EEEL has traditionally evaluated the overall performance and impact of its research programs in a variety of ways, including: monitoring outputs such as calibrations, SRMs, publications, participation in joint activities such as standards committees and cooperative research; expert-peer-review evaluation of output quality through the annual NRC Board on Assessment panel; and retrospective economic impact studies which sample the work in EEEL. Internally, EEEL management monitors performance through direct interactions with staff, Quarterly Management Reports, internal reviews, and Trip Reports. Additional quality checks include thorough review of all measurement services documentation for SRMs and Calibrations by MCOM (the EEEL Measurement Services Committee, comprising all EEEL division chiefs and EEEL Laboratory representative) and technical publication document reviews by WERB/BERB (Washington and Boulder Editorial Review Boards).

EEEL has also enjoyed a strong OU-level strategic planning effort. In 2002 the EEEL Management Team concluded a series of strategic planning meetings resulting in the document "EEEL Evaluation Criteria", which clearly and comprehensively articulates the mission and values of EEEL, and a consensus rationale for selection of EEEL programs and projects. At the highest level, the EEEL Evaluation Criteria consists of "Fit to Mission" (conformance test) and "Impact" (performance test) categories, with cascading sub-categories (for example, "Impact" is conceptually defined as the product of "Impact If Successful" and "Probability of Success") and detailed explanatory notes. A primary goal of this effort is to more actively engage divisions and bench-level staff in strategic planning efforts at all levels in EEEL.

The current Administration's goal to hold federal agencies more accountable for the funding they receive has resulted in recent OMB draft investment criteria for federally funded basic research in the areas of quality, relevance, and performance. These draft criteria are paraphrased below and interspaced with relevant EEEL evaluation mechanisms:

Quality — *Programs must use a clearly stated, defensible method for awarding a significant majority of their research grants and contracts, and periodically examine whether their portfolio of projects produces scientific and technical excellence. Draft guidance includes prospective review of awards and retrospective expert review of program quality.*

EEEL evaluates the quality of its programs through:

- Annual NRC Assessment panel (independent peer-review)
- Retrospective/prospective economic impact studies (EEEL has a long history of using these studies)
- Starts and Stops (annual 5% funding redistribution across EEEL, division prioritized proposals evaluated using EEEL Evaluation Criteria, relevance to NIST SFAs and other factors)
- Internal Reviews of EEEL Programs (This year's review of selected division projects explicitly used the EEEL Evaluation Criteria as the basis for evaluation and ranking, which provided input for the Starts and Stops)
- MCOM reviews of all Measurement Services documentation for SRMs, Standard Reference Data, and Calibrations
- WERB/BERB publication reviews

Relevance — *Research programs need to set a general direction for their investments, and program objectives and goals should be assessed by their relevance to agency missions, national needs, and the field(s) of study the program intends to address. Draft guidance includes definition of program direction/relevance and retrospective outcome review.*

EEEL evaluates the relevance of its programs through:

- Preparation of the EEEL Strategic Plan (2002)
- EEEL Evaluation Criteria (primarily through an evaluation of anticipated impact if successful, used for both prospective and retrospective internal reviews)
- Broad staff participation in relevant Standards committees
- Industry roadmaps (SEMATECH, OIDA, NEMI, NSIC, among others, in which many EEEL staff actively participate)
- Trip Reports (Required of all EEEL staff, used to communicate relevance of projects to industry needs, emerging needs and industry direction to management)
- Other direct interactions with industry

Performance — *Programs must demonstrate attentiveness to the health of their research enterprise and an ability to manage their programs in a manner that produces identifiable results, and agencies should develop objectives with annual performance outputs that show how outcomes will be reached. Draft guidance includes prospective assessment of program inputs and output performance measures, and demonstration of performance.*

EEEL evaluates the performance of its programs through:

- Quarterly Management Reports (Primary performance evaluation tool for EEEL management, each division prepares extensive quarterly reports detailing progress in all projects toward explicit deliverables and milestones with defined due dates. Much of this information is made directly available to Panel members as part of the peer-review process.)
- Annual Division Accomplishment Books (Each division published an annual accomplishment book containing explicit project deliverables and annual performance summaries)

- OMP SEMATECH score sheets (Initiated by NIST Deputy Director, outside customer evaluation of performance and relevance of OMP-funded projects, projects must have no low scores)